Willamette National Forest Pilot Road Analysis

Appendix D

Terrestrial Wildlife Process Paper

October 1998

Contents

Introduction

The road network on the Willamette National Forest is extensive, totaling over 7300 miles of paved and unpaved roads. This road network can significantly alter wildlife habitats and negatively impact wildlife populations. The negative effects of roads on wildlife can be classified into three general categories: (a) edge effects; (b) barriers to movement; and (c) avenues for resource extraction.

Edge effects

Roads and intensive timber harvesting are the major causes of forest fragmentation on the Willamette National Forest. Forest fragmentation can threaten native wildlife populations by eliminating blocks of continuous habitat or by degrading the quality of remaining habitat for those species sensitive to an increase in the amount of forest edge. Forest fragmentation exposes the organisms that remain in the fragment to the conditions of a different surrounding habitat, and consequently, to what have been termed ‘edge effects’. Edge effects are the result of the interaction between two adjacent habitats, when the two habitats are separated by an abrupt transition (edge) (Murcia 1995).

The ecology of forest edges is characterized by changes in biotic elements (parasites, predators, and herbivores) and abiotic elements (microclimate, disturbance regime), both of which have been documented in bird and plant communities (Paton 1994; Yahner et al. 1989). If exposure to the edge modifies the features of the forest beyond their range of natural intrinsic variation, then the fragment’s area will be effectively reduced for conservation purposes (Murcia 1995). Although the juxtaposition of two contrasting habitats can produce effects on both, our concern is the effect of edges on the remnant forest patches.

During the daytime, forest edges typically have lower humidity, higher air temperatures, higher soil temperatures, increased solar radiation, lower soil moisture, and higher windspeeds, than interior forest. Physical edge effects from roads are expected to be similar, although smaller in magnitude, than edge effects from clearcuts into forests. On the Willamette National Forest, microclimatic variables in clearcuts can extend up to 240 m into adjacent late-successional forest (Chen et al. 1993, 1995, 1996; Brosofske et al. 1997).

The direct and indirect effects of altered microclimate along the forest edge manifest themselves in several ways. For example, several studies have shown that depredation and parasitism rates of birds’ nests increase as forests are fragmented into smaller and smaller patches (Hartley et al. 1998; Paton et al. 1994; Keyser et al. 1998). Amphibian distributions and abundance (Demaynadier et al. 1998), as well as plant distribution and abundance (Fraver 1994), are also known to be influenced by proximity to edges. In addition to these effects, noise from dense vehicular traffic degrades habitat, especially for avian communities (Klein 1993; Reijnen et al. 1995; Reijnen et al. 1996), and big game such as deer and elk (Thomas et al. 1979; Lyon 1983; Lyon et al. 1985; Wisdom et al. 1986).

Barriers to movement

A second major impact of roads on wildlife is as a barrier to species movement. The barrier effect is sensitive to both road width and traffic density (Forman and Hersperger 1996). As road width and traffic density increase, roads become more effective barriers to movement (Reudiger 1996). Roadkilled animals are conspicuous examples of the barrier effect. Many species also avoid roads. In this case, most animals remain at some distance from roads, and rarely or never attempt to cross. Hence, a once continuous large population is fragmented into smaller subpopulations. When populations become subdivided, there is increased risk of demographic fluctuation, local extinction of subpopulations, less recolonization after local extinction, and a progressive loss of local biodiversity (Soule 1987).

Avenues for resource extraction.

The extensive network of Forest Service roads also creates opportunities for humans to extract natural resources. Indeed, the construction of the vast majority of the Willamette's road system was to extract timber. In addition to timber harvesting, many animals (e.g., deer, elk, and bear) are hunted, and most hunters camp and hunt close to roads. "Special products" such as fungi, lichens, berries, and mosses are increasingly being collected on the Forest, and firewood collecting has traditionally been a common activity on the Willamette. To reduce hazards for public and Forest Service activities, snags (standing dead trees) are routinely removed from near roadsides. Generally speaking, human influences on the forest are greatest near roads, and decrease steadily with distance from roads.

Road density as an index to measure ecological effects of roads

Road density is a useful measure of the ecological effects of roads in a landscape (Forman and Hersperger 1996). Road density is defined as the total length of miles per unit area (e.g., miles/sq. mile). As road density increases, edge effects, barriers to faunal movement, population fragmentation, and human access usually increase, leading to significant changes in the biological community.

With the availability of GIS (Geographic Information Systems), it is very easy to calculate road densities across the landscape and display the results on a map. In this report, we calculated road densities in habitats of concern (using a "moving window" analysis originally developed for grizzly bear habitat analysis) and displayed the results on maps. This allowed us to locate priority areas, or "hot spots", for potential, future road closures and decommissioning.

A caveat on road data used in these analyses

For this pilot analysis, we used the best road data available for the Willamette National Forest, the transportation layer in GIS. Although there are known inconsistencies in the quality of the data across the Forest (see *Section 4: Current Situation* of the Willamette National Forest Roads Analysis), we feel the accuracy of the layer is acceptable for setting priorities for most wildlife and TES (threatened, endangered, and sensitive species) issues. Nevertheless, an updated transportation layer that is consistent across the Forest is desired so that priorities can be established with a higher degree of accuracy and reliability.

Process Description

List of issues and key questions

In the beginning of this analysis, we considered answering fourteen different questions pertaining to the impact of roads on wildlife and their habitats (**Table 1**). Of this original list of issues and key questions, we carried out analyses for the eight questions for which we had sufficient data to do so (questions 1-8 in Table 1). Because the results from two of the eight analyses (questions 7 and 8, Table 1) provided little additional insight, the results from these two questions are not reported here.

The six questions addressed in this document provide two general types of information:

a. *Quantitative* information on the overall, negative impact that roads have on habitats of concern (Questions 1-3).

b. *Geographically* explicit information on where priority areas, or “hotspots”, are located (Questions 4-6). The maps produced to address Questions 4-6 will probably be the most useful for identifying areas of concern for wildlife.

How each key question was addressed

In this section, we briefly discuss the methodology used to address each of the six questions we analyzed for this report (Table 1).

Question 1: ***Roadsheds created by state highways***

This was a very simple analysis, conducted at the Forest scale. To determine how the state highway system divides the Forest into major habitat blocks (i.e., roadsheds), we utilized the GIS layers with the road system (tran), and the boundary of the WNF (wil_bnd). From these two layers, we generated a new polygon coverage that shows the roadsheds of the WNF (**Map W1a**).

Questions that were analyzed in this report

1. How does the state highway system divide the Forest into major habitat blocks, or "roadsheds" (W1)?
2. Of the total amount of spotted owl habitat on the Forest, how much is impacted by the "edg effects" of roads (TW1, TW4, TW5)?
3. Of the total amount of interior, late-successional, habitat on the Forest, how much is influenced by the "edge effects" of roads (TW1, TW4, TW5)?
4. What are the current road densities in riparian reserves (W2)?
5. What are the current road densities in connected, late-successional, habitat in no-harvest status (TW1, TW4, TW5)?
6. Where does the current density of open roads exceed Willamette Land Management Plan objectives for big game (i.e., deer and elk) (W3)?

Questions that were considered and analyzed, but not included in this report*

7. What are the current road densities in spotted owl habitat (TW1, TW4, TW5)?
8. What are the current road densities in interior, late-successional, habitat (TW1, TW4, TW5)

Questions that were considered, but not analyzed, in this report**

9. How and where do roads affect special and unique habitats (e.g., caves, cliffs, meadows) (TW7)?
10. How and where does the road system affect the removal of habitat structural components (e.g., hazard trees/tree removal along roads, woody debris for firewood) (TW10)?
11. Which late-successional related species are affected by roads and how are they affected (W
12. How and where does the road system affect direct mortality (e.g., road kill, legal and illegal hunting) (TW8, TW9)?
13. How do road maintenance chemicals (e.g., de-icers, road oils) used on all roads affect wildlife? Which chemicals have adverse effects? (W5)
14. How, when, and where does the road system affect habitat of threatened, endangered, sensitive (e.g., wolverine), and proposed (e.g., Canada lynx) species habitat due to the proximity of roads to key habitat such as nesting, roosting, denning, and foraging areas (W

Table 1. Issues and key questions pertaining to the effects of roads on wildlife and their habitats. The number-letter combinations beginning with TW refer to specific questions developed by the National Roads Team. The number-letter combinations beginning with W refer to specific questions developed by the Willamette National Forest Wildlife Department.

*These two analyses were similar in scope and approach to Question 5. Due to their similarities, these two analyses identified the same resource "hot spots" as Question 5. Therefore, we only included the results for Question 5.

**Questions 9-13 were not analyzed because the data to address them were non-existent or inadequate. Question 14 could have been analyzed for spotted owls, but concerns for this species were already addressed with Questions 2-5, and 7-8. Question 14 is more appropriately addressed with project-level analyses. Question 9 was partially analyzed by the Botany Department.

Question 2: ***Edge effects on spotted owl habitat***

We conducted this analysis at the Forest scale, including all land allocations except wilderness and roadless areas. Results were then summarized by roadshed. The main GIS layers used for this analysis were: transportation (tran), roadshed (roadshed), and spotted owl habitat (ohab). The key logical steps in this analysis were:

1. *To generate a coverage showing the "edge effects" from roads.* Published results from the WNF (Chen et al. 1993, 1995, 1996; Brosofske et al. 1997) show that microclimatic variables (e.g., temperature, wind speed, and relative humidity) in clearcuts can extend up to 240 m (787 feet) into adjacent late-successional forest, while biological variables (e.g., sun scald, windthrow, response of understory plants) can be measured up to 120 m (394 feet). Although roads *per se* are expected to generate less edge effects than clearcuts, the vehicular and human uses of roads generate effects (e.g., noise, poaching, removal of snags and trees that pose hazards, etc.) that clearcuts do not. Based on these considerations, we considered edge effects from state highways to extend 240 m (787 feet), and from all other road types to extend 120 m (394 feet). Therefore, we generated an "edge effects" coverage by buffering state highways by 240 m (787 feet) and all other roads by 120 m (394 feet) (railroads and trails were not included in this analysis). A map was created that shows the roadsheds (not including Wilderness and Roadless Areas) with the edge effects erased from it (**Map W1b**).
2. *To create a coverage showing spotted owl habitat in each roadshed.* This is a simple GIS procedure to assign a roadshed value to each polygon of spotted owl habitat. From the spotted owl habitat layer, we selected only the "typical nesting" and "typical roosting" habitats.
3. *To erase the "edge effects" coverage from the roadshed coverage.* This step generates a new coverage that shows only the spotted owl habitat that is not impacted by edge effects from roads.

Question 3: ***Edge effects on interior habitat***

We conducted this analysis at the Forest scale. This analysis was identical to the analysis for Question 2, except that interior, late-successional habitat was substituted for spotted owl habitat. An interior habitat layer was created from the seral stage data in the GIS layer, called LSR VEG, created during the Mid-Willamette LSR Assessment (USDA/USDI 1998). Because the Mid Willamette LSR Assessment did not cover watersheds north of the Little North Santiam River, the resulting interior forest habitat also does not include these areas. However, because the excluded area is currently proceeding through a process to become the Opal Creek Wilderness area, its exclusion from this analysis is not a problem (since we excluded Wilderness and Roadless areas from analyses for Questions 2-3).

Seral stages present in the LSRVEG layer are the following: (a) early; (b) early-mid; (c) mid; (d) late-mature; and (e) large-old growth. Actual assignment of each stand to a seral stage was dependent on dbh, plant association, and age. For more information on how seral stages were assigned, see the Mid-Willamette LSR Assessment (1998). To create the interior habitat layer, "late-mature" and "late-old growth" seral stages were "buffered" inward 400 feet.

Question 4: ***Road densities in riparian reserves***

We conducted this analysis at the Forest scale. We used the transportation (tran) and riparian reserve (strbuf) GIS layers for this analysis. With these two layers as starting blocks, we then ran a sequence of GIS steps to calculate the density of roads within and adjacent to riparian reserves. This sequence of steps, called a "moving window analysis" was written as an aml (Arc Macro Language). The product of this analysis is a map (**Map W2**), which highlights the stretches of riparian reserves with the highest road densities.

Question 5: ***Road densities in connected, late-successional habitat***

We conducted this analysis at the Forest scale. The Northwest Forest Plan established a system of reserves to provide connected late-successional habitat across the landscape for late-successional species. There are two basic kinds of reserves: large reserves and riparian reserves. The large reserves (e.g., Late-Successional Reserves, Administratively Withdrawn Lands, and Congressionally Reserved Lands) are often connected through the linearly shaped riparian reserves. It is not always necessary for patches of late-successional habitat to be adjacent for late-successional species to successfully disperse among patches. Many species can cross short distances of other habitat types before arriving at late-successional habitat. For this analysis, we assumed that low-mobility, small-bodied species can travel no more than about 350 m (1148 feet) through non-late-successional habitat. ***Connected late-successional habitat****, then, consists of late-successional habitat in a no harvest status (this includes all reserved lands and land with unsuitable soils for harvest) buffered by 191 m (627 feet).* With the pixel size we used in GIS (one pixel = one acre), 191 m (627 feet) is as close to half of the maximum gap distance of 350 m (1148 feet) as we could get. This is the same layer of connected, late-successional habitat that was used for the Mid-Willamette Late-Successional Reserve Assessment (USDA/USDI 1998).

With this connectivity layer, we then ran the same "moving window" analysis as we did for Question 4. The product of this analysis is a map (**Map TW4**) which highlights the areas of connected, late-successional habitat where road densities are relatively high.

Question 6: ***Road densities in BGEAs***

We conducted this simple analysis at the Forest scale. Two GIS layers were used: transportation (tran) and Big Game Emphasis Area (bgea). From the transportation layer (tran), we selected only those roads that are open. We then calculated the miles of open road per Big Game Emphasis Area. The results from this analysis are displayed on the map, **Map W3**.

Results and Interpretation

Question 1: ***Roadsheds created by state highway***

The state highway system divides the Forest into six distinct roadsheds (**Map W1a**), that vary greatly in size (**Table 2**). Because many species will not cross major highways, or suffer high mortality rates when attempting to cross them (due to collisions with vehicles), roadsheds may represent regions into which some populations are subdivided.

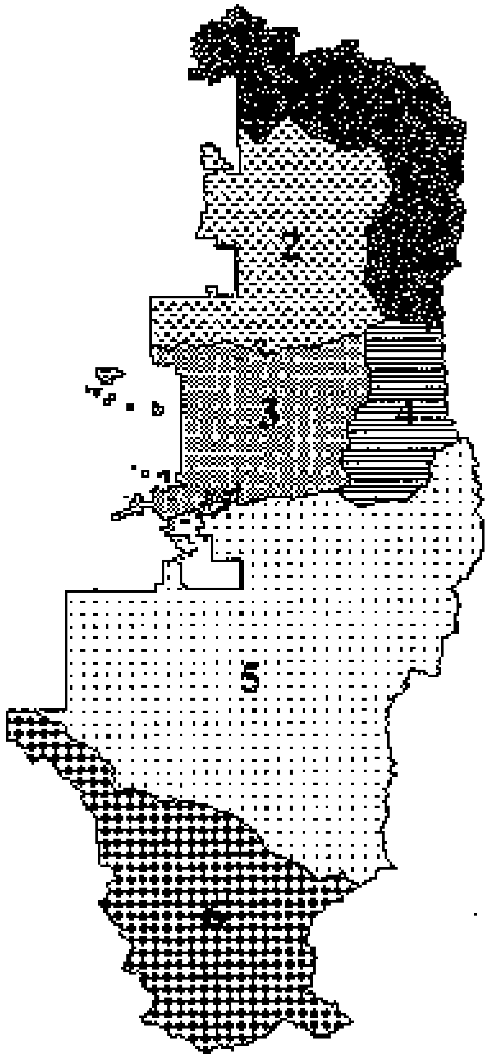
Roadshed	Area (sq. miles)
1	171
2	301
3	272
4	67
5	609
6	460

Table 2. Area of each roadshed. Wilderness and Roadless Areas not included in calculations.

Generally speaking, the smaller the roadshed, the higher the probability that highly mobile, terrestrial organisms (e.g., carnivores) will encounter a major highway. Of the six roadsheds on the Willamette, Roadshed 4 is tremendously smaller than the other five. Therefore, an individual whose home range overlaps or borders the highways will have a higher probability of encountering high density, high velocity traffic if it attempts to disperse than individuals whose home ranges do not overlap or border highways.

Map W1b offers a striking representation of how much land is impacted from the edge effects of roads. In each roadshed, over 40 % of all the land is impacted by edge effects (**Figure 1**). We consider this to be a very high percentage of land to be negatively impacted by roads. Roadshed 4 has the most land that is affected by edge effects from all road types, followed by Roadshed 2 (**Map W1b**, **Figure 1**).

Map W1a. The Six Roadsheds on the Willamette NF.



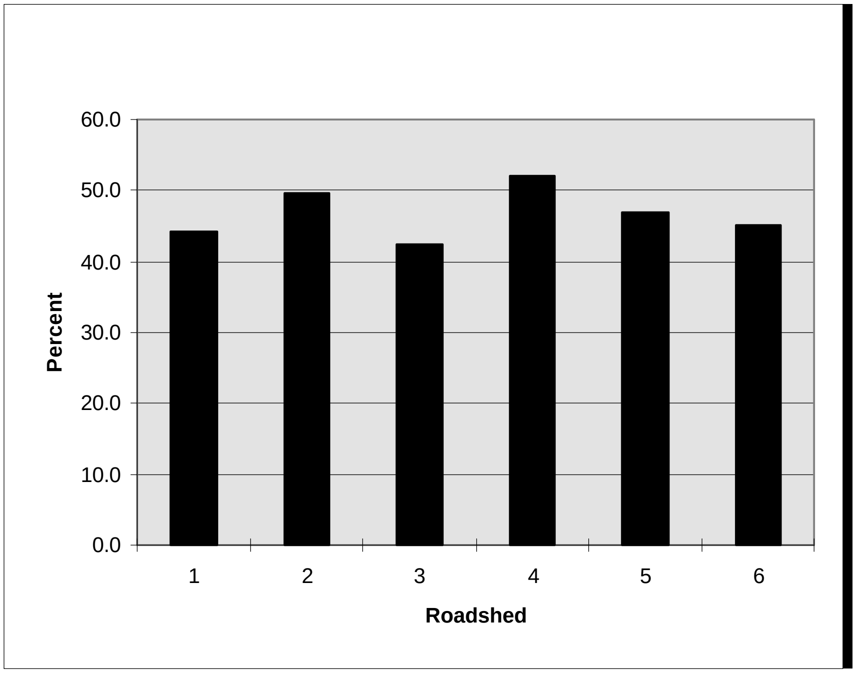


Figure 1: The percentage of each roadshed that is affected by edge effects from roads. Roadshed 4 has the highest percentage of its total area impacted by edge effects, while Roadshed 3 is least affected. Wilderness and Roadless Areas not included in calculations.

Question 2: *Edge effects on spotted owl habitat*

The amount of spotted owl habitat varies greatly among roadsheds, from a low of 26.9 square miles in Roadshed 4 to a high of 270 square miles in Roadshed 5 (**Figure 2**). Edge effects impact 31 - 49 percent of the spotted owl habitat per roadshed (**Figure 3**). Twelve percent more spotted owl habitat in Roadshed 4 is impacted by edge effects than in any other roadshed (**Figure 3**).

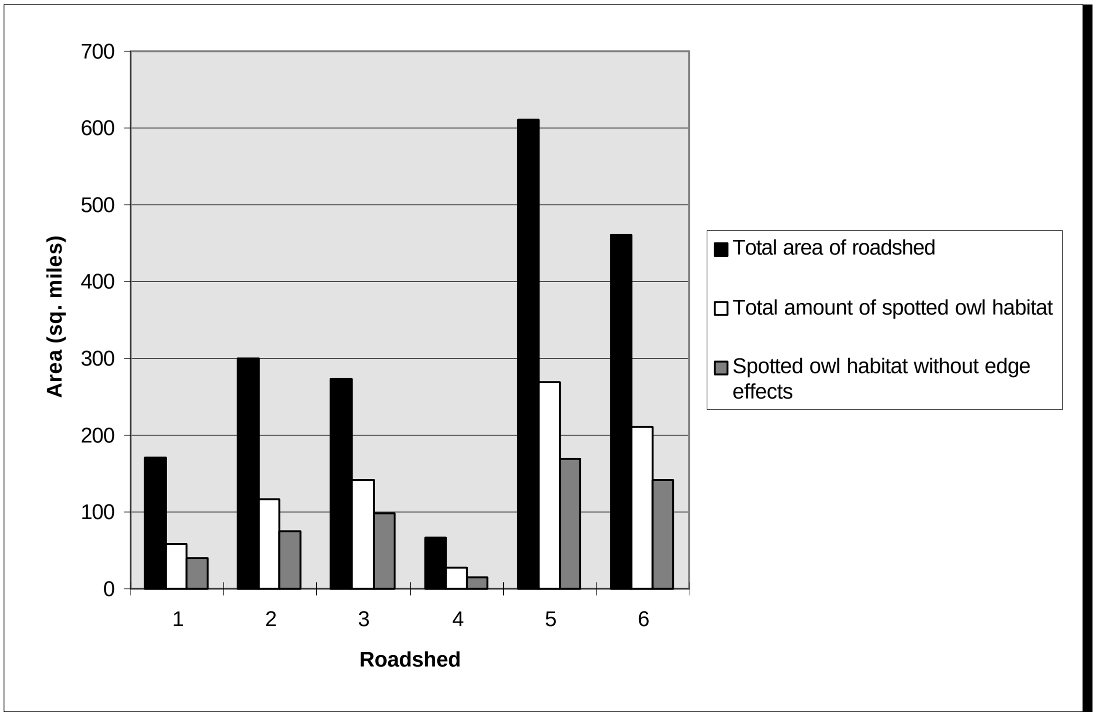


Figure 2. Comparison of roadsheds based on total area, area of spotted owl habitat, and area of spotted owl habitat that is not affected by edge effects from roads. Wilderness areas and roadless areas are not included in these calculations.

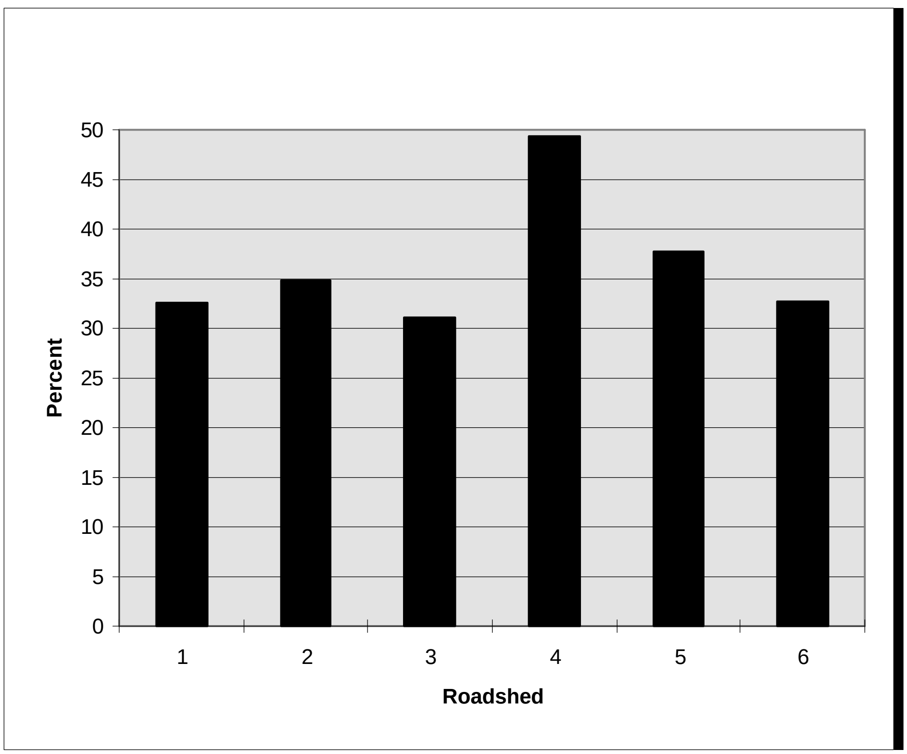


Figure 3. The percentage of spotted owl habitat that is impacted by edge effects from roads. Spotted owl habitat in Roadshed 4 is most impacted by roads, while owl habitat in Roadshed 3 is least affected by roads. Wilderness areas and roadless areas are not included in these calculations.

Question 3: *Edge effects on interior habitat*

The amount of interior habitat varies greatly among roadsheds, from a low of 7.7 square miles in Roadshed 1 (6 percent of the roadshed) to a high of 60.1 square miles in Roadshed 6 (16 percent of the roadshed) (**Figure 4**). Of the current amount of interior habitat in each roadshed, 22 - 41 % is impacted by edge effects (**Figure 5**). Interior habitat in Roadshed 4 is impacted to a much greater extent by edge effects than the other roadsheds (**Figure 5**).

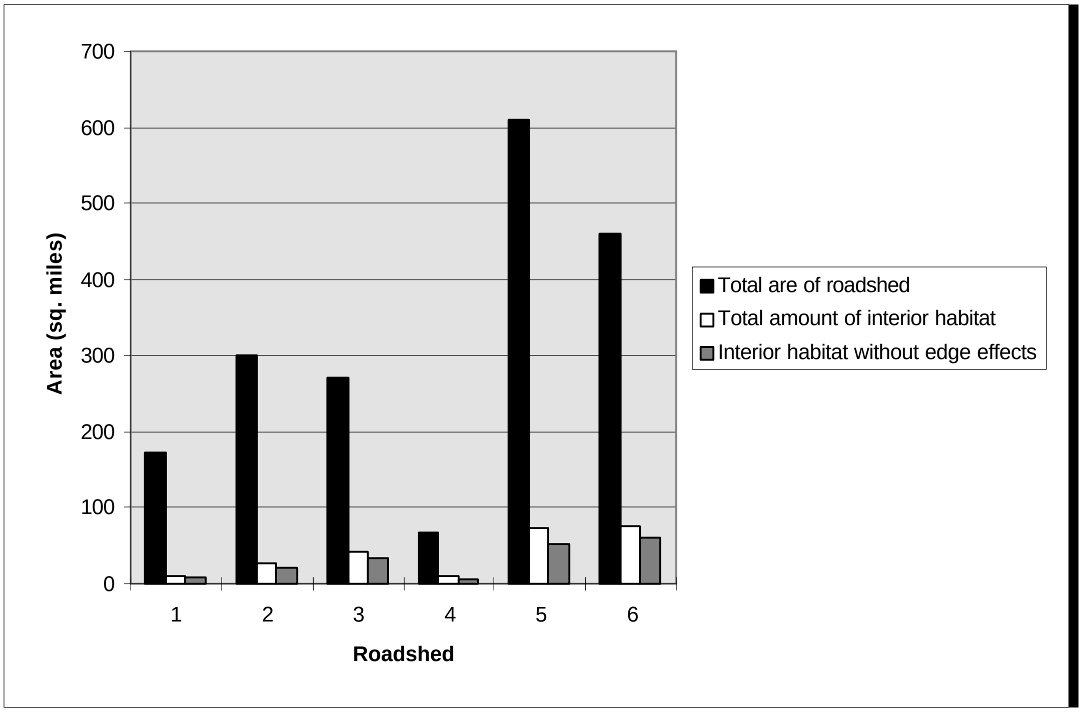


Figure 4. Comparison of roadsheds based on total area, area of interior habitat, and area of interior habitat that is not affected by edge effects from roads. Wilderness areas and roadless areas are not included in these calculations.

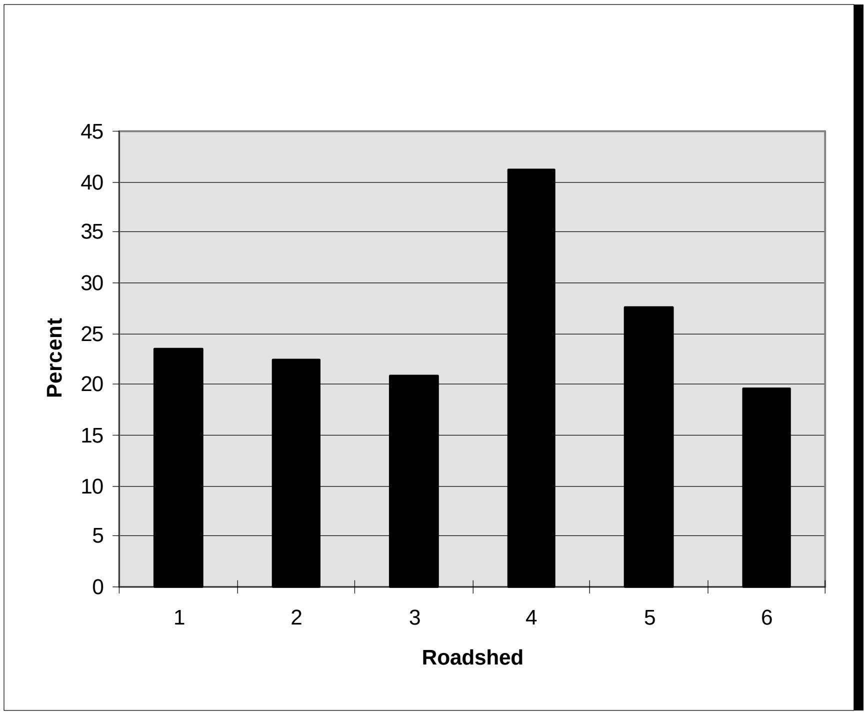


Figure 5. The percentage of interior habitat that is impacted by edge effects from roads. Interior habitat in Roadshed 4 is most impacted by roads, while interior habitat in Roadshed 6 is least affected by roads. Wilderness areas and roadless areas are not included in these calculations.

Question 4: *Road densities in riparian reserves*

Map W2 highlights the areas of concern based on road densities in riparian reserves. The highest priority areas are those that have road densities of 4-5 miles/sq. mile. In several areas on this map, the riparian reserve width appears to be much larger than in the other areas. These areas represent places where the riparian reserve intersects a primary management zone for a threatened or endangered raptor. On the south end of the Forest, there is a priority area (4-5 mi/mi2) close to Road 23 that is an important raptor management zone. This area should be considered a particularly high priority, given the conservation importance of threatened and endangered species.

Question 5: *Road densities in connected, late-successional habitat*

Map TW4 highlights areas of concern based on road densities in connected, late-successional habitat. The highest priority areas are those that have road densities of 6-8 miles/sq. mile. Note that several of the areas in the highest road density categories are in Late-successsional Reserves (LSRs). Because these areas are supposed to be managed for late-successional dependent species, it is of concern that some of the highest road densities for connected, late-successional habitat occurs in the LSRs. The Mid-Willamette Late-Successional Reserve Assessment (USDA/USDI 1998) also discusses the problem of roads within LSRs. This LSR Assessment should be consulted for a more detailed discussion of the role that roads may play in the management of the LSRs.

Question 6: ***Road densities in BGEAs***

Of the 53 High Emphasis Areas for big game on the WNF, 26 (49%) have road densities that exceed WNF Land Management Plan objectives. Of the 110 Moderate Emphasis Areas for big game, 36 (33%) have road densities that exceed the objectives. On an acreage basis, 218,493 acres (43%) of the land in the High Emphasis Level exceeds the objectives, whereas 270,163 acres (29%) of the land in Moderate Emphasis Level exceeds the objectives (**Table 3**). **Map W3** displays the Big Game Emphasis Areas where WNF Land Management Plan objectives for big game are not being met.

Big Game Emphasis Level	Total # acres in Emphasis Level	# acres that exceed objectives for Big Game (% of total acreage)
High	508,533	218,493 (43%)
Moderate	930,321	270,163 (29%)
Low	352,025	0 (0 %)

Table 3. Number of acres that exceed objectives for big game, by emphasis level.

Summary of results

High road densities can pose problems for wildlife populations because of the biological and abiotic edge effects associated with roads. On the six roadsheds of Willamette National Forest, 31 - 49 percent of the current spotted owl habitat, and 22-41 percent of the interior habitat, is impacted by edge effects. These statistics indicate that a large percentage of late-successional habitat, upon which many plant and animal species depend (USDA/USDI 1994), incurs negative impacts from roads.

Non-late successional dependent species, such as elk, can also be negatively impacted from high road densities. Our analysis of road densities in Big Game Emphasis Areas shows that current road densities exceed management objectives for big game in 33% of Moderate Emphasis Areas and 49% of High Emphasis Areas.

Given the high road densities on the Forest, where should efforts be taken to close or decommission roads to benefit wildlife? We produced **three maps (Maps W2, TW4, and W3)** to help prioritize areas of the Forest where roads should be closed or decommissioned. Each map shows priority areas, or hot-spots, based on the impacts of roads to one particular species or habitat type. These maps should be used in conjunction with the maps produced by other natural resource departments (e.g., botany, fisheries, and hydrology). The highest priority sites for management action should be those where there is congruence, or overlap, among two or more maps. For example, if there is a riparian reserve with very high road densities (from Map W2), that also overlaps a stream with endangered fish species, or an area with high potential for landslides, then that would be a priority area. Areas identified as a priority by one map, but not on any others, may still be a Forest-wide priority, but the trade-offs of focusing on one site to the expense of other sites must be weighed carefully.

Process Critique

Overall, I felt the process used for the pilot roads analysis was effective and efficient. I felt the leadership team did a solid job of keeping all the participants informed of timelines and expectations. I felt the composition of the analysis team was sufficiently experienced, and encompassed a wide spectrum of expertise. From my perspective, the lack of public involvement made the analysis much easier to complete in a timely fashion. However, public involvement may have generated ideas or issues that we did not think of ourselves.

The greatest drawback to the process was the lack of updated GIS data. Most importantly, the transportation (roads) layer does not contain consistently good data across the forest. Certain Districts have been very conscientious about digitizing each road that exists on their District, while other Districts have not. Therefore, attempting to prioritize areas of concern based on road densities may be biased towards Districts that have updated their GIS layer. Districts that have not digitized all their roads may, in reality, have more roads (and therefore, more need to close or decommission roads) than the other Districts, but because they are not in GIS, our analyses would not include them.

In addition to the roads layer, several of the forest-wide layers for wildlife have not been updated recently. While each District may have updated layers for species of concern, it was not possible with the time frame of this project to gather all the data and convert it into forest-wide layers. We are currently rectifying this situation so that all of our GIS wildlife layers will be standardized across all Districts and annually updated.

Once this updating process is complete, we would be able to address the following questions:

1. *Are any peregrine falcon management areas negatively affected by roads?*
2. *Are any bald eagle management areas negatively affected by roads?*
3. *What portions of Canada lynx and wolverine habitat are most impacted by roads?*

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